LEGEND

$\underset{U}{\overset{D}{\rule{1cm}{0.4pt}}}$	Fault
1050	Line of Equal Head (Interval=5ft)
	Metamorphic/ Igneous Hill
	Boundary of No Flow Area
5B *	Imaginary Particle Location at end of simulation
3 ○	Extraction Area
⟨	Imaginary Particle Pathline

Shandin Hills

Dry Cells

Dry Cells

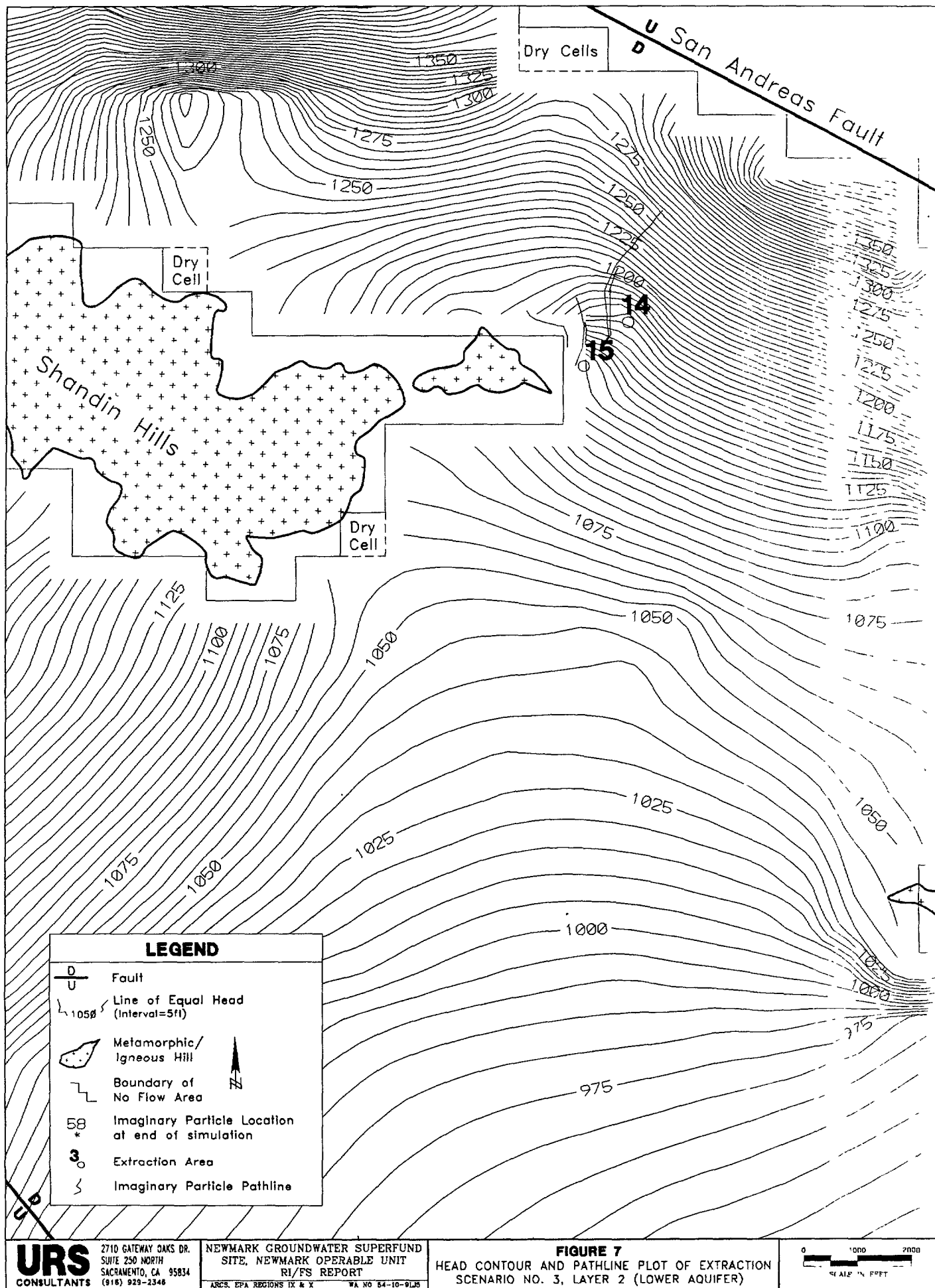U D San Andreas Fault

Dry Cell

Dry Cell

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FIGURE 6
HEAD CONTOUR AND PATHLINE PLOT OF EXTRACTION
SCENARIO NO 3, LAYER 1 (UPPER AQUIFER)

0   1000   2000
SCALE IN FEET

The map shows head contour lines and pathlines. Labeled contour values include: 1350, 1325, 1300, 1275, 1250, 1225, 1200, 1175, 1150, 1125, 1100, 1075, 1050, 1025, 1000, 975.

Labels on map: Dry Cells, San Andreas Fault, Dry Cell, Shandin Hills, 14, 15, U, D

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FIGURE 7
HEAD CONTOUR AND PATHLINE PLOT OF EXTRACTION
SCENARIO NO. 3, LAYER 2 (LOWER AQUIFER)

SCALE IN FEET
0   1000   2000

Appendix M

Table 7

EXTRACTION AREA LOCATIONS & PUMPING RATES
FOR EXTRACTION SCENARIO NO. 3

Extraction Area	Model Cell (x,y,z)	Screen Interval (ft)	Approximate Location	Pumping Rate (gpm)
Middle Area of Newmark Plume				
14	(33,22,1)	995 to 1216[a]	150' E/of Sierra Way; 200' N/of Ralston Ave.	2000
15	(32,23,1)	1030 to 1190[a]	100' E/of Mt. View Ave.; 200' S/of 39th St.	2000

Note: Extraction Area no. 1 was eliminated after Run 32A0612.
[a] Initial head in layer 1 (upper aquifer). The screen interval in layer 1 equals the head value in layer 1 minus the bottom elevation for layer 1.

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Table 8

IMAGINARY PARTICLE LOCATIONS FOR EXTRACTION SCENARIO NO. 3

Particle	Model Cell (x,y,z)	Particle	Model Cell (x,y,z)
1	(34,20,1)	4	(32,22,1)
2	(33,21,1)	5	(32,22,2)
3	(33,21,2)	6	(31,22,1)

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Table 9

INPUT AND OUTPUT FILES FOR EXTRACTION SCENARIO NO. 3

| | Rootname | | | | |
Run No.	Modification	Date	Extension	Filename	Type of File
32	B	06/12/92	BAS	32B0612.BAS	MODFLOW input file
32	B	06/12/92	BCF	32B0612.BCF	MODFLOW input file
32	B	06/12/92	OC	32B0612.OC	MODFLOW input file
32	B	06/12/92	PCG	32B0612.PCG	MODFLOW input file
32	B	06/12/92	RIV	32B0612.RIV	MODFLOW input file
32	B	06/12/92	WEL	32B0612.WEL	MODFLOW input file
32	B	06/12/92	GHB	32B0612.GHB	MODFLOW input file
32	B	06/12/92	EVT	32B0612.EVT	MODFLOW input file
32	B	06/12/92	BCF	32BCELL.BCF	MODFLOW cell-by-cell flow file
32	B	06/12/92	RIV	32BCELL.RIV	MODFLOW cell-by-cell flow file
32	B	06/12/92	WEL	32BCELL.WEL	MODFLOW cell-by-cell flow file
32	B	06/12/92	GHB	32BCELL.GHB	MODFLOW cell-by-cell flow file
32	B	06/12/92	EVT	32BCELL.EVT	MODFLOW cell-by-cell flow file
32	B	06/12/92	OUT	32B0612.OUT	MODFLOW output file
32	B	06/12/92	UFM	32BHEAD.UFM	MODFLOW unformatted head file
32	B	06/12/92	INP	32BPATH.INP	PATH3D input file
32	B	06/12/92	OUT	32BPATH.OUT	PATH3D output file
32	B	06/12/92	DAT	P3DCNFG.DAT	PATH3D data file
32	B	06/12/92	DAT	P3DPLOT.DAT	PATH3D data file
32	B	06/12/92	DAT	P3DFRONT.DAT	PATH3D data file
32	B	06/12/92	DAT	P3DCAPT.DAT	PATH3D data file
32	B	06/12/92	DAT	FRONTXYZ.DAT	PATH3D data file used with SURFER
32	B	06/12/92	DAT	PATHXYZ.DAT	PATH3D data file used with SURFER
32	B	06/12/92	BLN	PATHXY.BLN	PATH3D data file used with SURFER
32	B	06/12/92	BLN	PATHXZ.BLN	PATH3D data file used with SURFER
32	B	06/12/92	BLN	PATHYZ.BLN	PATH3D data file used with SURFER

Table 9 (Cont'd.)

INPUT AND OUTPUT FILES FOR EXTRACTION SCENARIO NO. 3

| | Rootname | | | | Type of |
Run No.	Modification	Date	Extension	Filename	File
32	B	06/12/92	GRD	32BCNTR.GRD	SURFER grid file of head contours
32	B	06/12/92	GRD	32BCNTR1.GRD	SURFER grid file of head contours
32	B	06/12/92	PLT	32BCNTR.PLT	SURFER plot file of head contours
32	B	06/12/92	PLT	32BCNTR1.PLT	SURFER plot file of head contours
32	B	06/12/92	DAT	XTRWELLS.DAT	Data file containing locations of extraction wells

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1   ■   Initially in Run 32A0612, three extraction areas were placed adjacent to the northeast edge of
2   Shandin Hills and arranged in a northeast/southwest lineament. Extraction area no. 13 was
3   located on the northeast end and extraction area no. 15 was located on the southwest end.
4   Extraction areas no. 13 and 14 were pumped at a rate of 2000 gpm and extraction area no. 15
5   (next to Shandin Hills) was pumped at a rate of 1000 gpm. One imaginary particle did migrate
6   between extraction area nos. 14 and 15.

7   ■   In the second simulation (Run 32B0612), extraction area no. 13 was eliminated and the pumping
8   rate for extraction area no. 15 was increased to 2000 gpm. All the imaginary particles were
9   captured by the end of the second year of simulation;

10   ■   In the third simulation (Run 32C0612), extraction area no. 14 was eliminated leaving extraction
11   area no. 15 operating. However, one imaginary particle, originating northwest of extraction area
12   no. 15, escaped the capture zone; and

13   ■   The extraction area specifications for Run 32B0612 (the second simulation) were used in
14   extraction scenario no. 3 since all six imaginary particles were captured. Table 7 gives the
15   locations and pumping rates for extraction area nos. 14 and 15.

16   **7.0 EXTRACTION SCENARIO NO. 4**

17   **7.1 Objectives**

18   The objectives for extraction scenario no. 4 were:

19   ■   Quickly estimate the number, locations, and pumping rates of extraction areas required to capture
20   the downgradient edge of the Newmark plume within five years by using extraction areas along
21   the centerline of the Newmark plume;

22   ■   Avoid creation of dry cells in the area east of Shandin Hills during the simulation; and

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1   ■   Minimize extraction of uncontaminated groundwater.

2   **7.2 Procedure and Data**

3   No prior simulations were made before the optimum simulation (Run 38A0720) was achieved for extraction

4   scenario no. 4. The procedure described below was followed for achieving optimum Run 38A0720:

5   ■   Run 38A0720 was made using MODFLOW that ran for a time span of five years. The transient-

6   state flow model, simulated and calibrated for the time period between January 1986 to December

7   1990 was used as the basis for Run 38A0720. The input data (including well pumpage) and

8   boundary conditions used in the calibration of the transient-state flow model were applied to Run

9   38A0720 for the five years of the simulation. The input data and boundary conditions area

10   described in more detail in Section 3.0;

11   ■   Five extraction areas were added to the well input file for remediation of the downgradient edge

12   of the Newmark plume. These five extraction areas were located along the centerline of the

13   lower portion of the Newmark plume. Due to a limitation in the MODFLOW program,

14   extraction of groundwater from the project flow model was not restricted to separate zones within

15   each model layer. Therefore, extraction area nos. 16 through 18 were screened throughout layer

16   2 and extraction area nos. 19 and 20 were screened throughout layer 1. For layer 1 of the

17   project flow model, the screen interval equaled the head value minus the bottom elevation for

18   layer 1. The screen interval for layer 1 changed when the head in layer 1 changed during the

19   simulation. Table 10 gives the locations of the extraction areas, their pumping rates and screen

20   intervals used in the simulation;

21   ■   PATH3D was applied to MODFLOW input data, output and the unformatted head files for Run

22   38A0720. A grid file of the heads was created through the application of PATH3D. Also,

23   pathlines were created for 37 imaginary particles placed along the outer perimeter of the lower

24   two-thirds of the Newmark plume. Table 11 gives the locations of the imaginary particles; and

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Table 10

EXTRACTION AREA LOCATIONS & PUMPING RATES
FOR EXTRACTION SCENARIO NO. 4

Extraction Area	Model Cell (x,y,z)	Screen Interval (ft)	Approximate Location	Pumping Rate (gpm)
Centerline of Newmark Plume				
16	(32,36,2)	160 to 650	100' E/of Mt. View Ave.; 250' N/of 18th St.	4000
17	(32,34,2)	260 to 650	100' E/of Mt. View Ave.; 200' N/of Highland Ave.	3000
18	(32,32,2)	370 to 690	Mt. View Ave.; 150' N/of 27th St.	3000
19	(33,30,2)	1000 to 1059[a]	200' E/of Sierra Way; 200' S/of 30th St.	2000
20	(33,28,2)	1005 to 1088[a]	200' E/of Sierra Way; 300' N/of Marshall Blvd.	2000

[a]   Initial head in layer 1 (upper aquifer). The screen interval in layer 1 equals the head value minus the bottom elevation for layer 1.

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Table 11

IMAGINARY PARTICLE LOCATIONS FOR EXTRACTION SCENARIO NO. 4

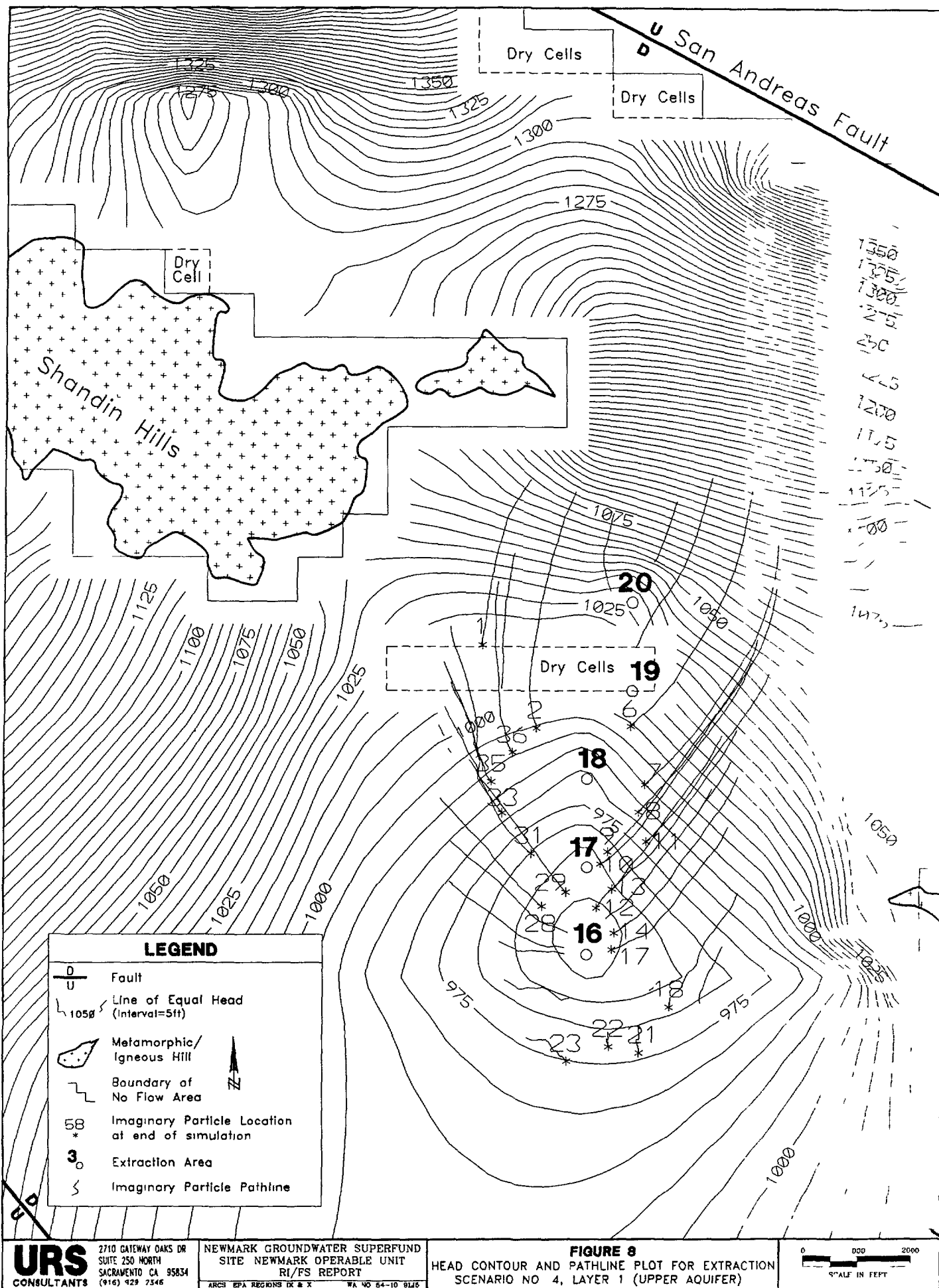| Particle(s)	Model Cell (x,y,z)	Particle(s)	Model Cell (x,y,z)
1	(31,26,1)	20	(34,37,2)
2	(32,26,1)	21	(33,38,2)
3	(33,26,1)	22	(32,38,2)
4	(34,26,1)	23	(31,38,2)
5	(35,26,1)	24	(30,37,2)
6	(36,26,1)	25	(30,36,2)
7	(36,27,1)	26	(29,35,2)
8	(36,28,1)	27	(29,34,2)
9	(36,29,1)	28	(29,33,2)
10	(36,30,1)	29	(29,32,1)
11	(36,30,2)	30	(29,32,2)
12	(35,31,1)	31	(29,31,1)
13	(35,31,2)	32	(29,31,2)
14	(35,32,1)	33	(29,30,1)
15	(35,32,2)	34	(29,30,2)
16	(35,33,2)	35	(29,29,1)
17	(35,34,2)	36	(30,28,1)
18	(35,35,2)	37	(30,27,1)
19	(35,36,2)		

1   ■   SURFER was used to produce plots of the head contours and pathlines created during the
2   application of PATH3D.

3   **7.3 Results and Summary**

4   The head contour plots for layers 1 and 2 (38ACNTR1.PLT and 38ACNTR2.PLT) and the PATH3D
5   output file for Run 38A0720 were analyzed. Figures 8 and 9 display the head contour plots for layers 1
6   and 2, respectively. These figures also display the extraction areas and the imaginary particles with their
7   pathlines. Table 12 lists the MODFLOW, PATH3D and SURFER files associated with Run 38A0720.
8   The results and summary of the analysis are listed below:

9   ■   Only one simulation (Run 38A0720) was run for extraction scenario no. 4. Five extraction areas
10   were placed along the centerline of the lower portion of the Newmark plume. They were
11   arranged in a north/south lineament and spaced approximately 820 feet apart from one another.
12   Extraction area no. 16 was located approximately 1600 feet north of the downgradient edge of
13   the Newmark plume and extraction area no. 20 was located in the center of the Newmark plume,
14   adjacent to the southeast edge of Shandin Hills;

15 ■   All 37 imaginary particles were pulled towards the extraction areas except four imaginary
16   particles located at the downgradient edge of the Newmark plume in layer 2 (the lower aquifer).
17   The four imaginary particles were, however, slowed down considerably and did not move more
18   than 1000 feet each during the five years of simulation. The four imaginary particles were
19   migrating slowly towards the southeast direction; and

20 ■   The pumping scenario described above produced a capture zone in layer 2 (the lower aquifer) that
21   appeared just large enough to capture the four stray imaginary particles in 35 years of simulation.
22   Therefore, the pumping rates for extraction area nos. 16 and 17 were maintained. For layer 1
23   (the upper aquifer), the capture zone extended approximately 1.0 mile downgradient from the
24   edge of the Newmark plume. However, the extraction area specifications remained as described
25   above because the contamination was believed to be concentrated in layer 2 (the lower aquifer).

LEGEND

$\frac{D}{U}$ ———	Fault
$\searrow$ 105ø $\swarrow$	Line of Equal Head (Interval=5ft)
⬡	Metamorphic/ Igneous Hill
⌐⌐	Boundary of No Flow Area
58 *	Imaginary Particle Location at end of simulation
3 ○	Extraction Area
ζ	Imaginary Particle Pathline

San Andreas Fault

Dry Cells
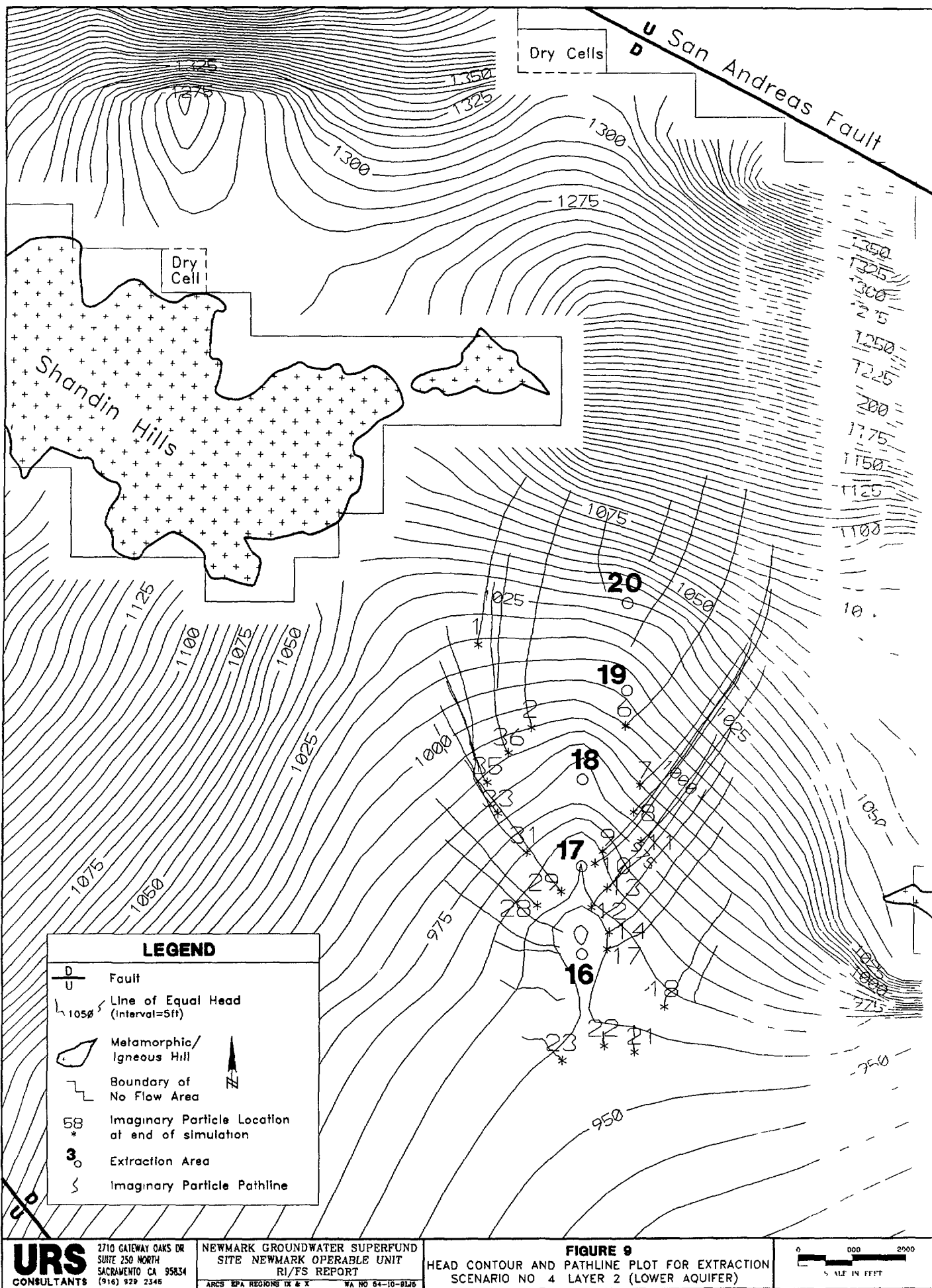
Dry Cells

Dry Cell

Shandin Hills

Dry Cells

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FIGURE 8
HEAD CONTOUR AND PATHLINE PLOT FOR EXTRACTION
SCENARIO NO 4, LAYER 1 (UPPER AQUIFER)

SCALE IN FEET

Dry Cells

U D San Andreas Fault

Dry Cell

Shandin Hills

20

19

18

17

16

LEGEND

D/U ——— Fault

1050 Line of Equal Head (Interval=5ft)

Metamorphic/ Igneous Hill

Boundary of No Flow Area

58 * Imaginary Particle Location at end of simulation

3 o Extraction Area

Imaginary Particle Pathline

FIGURE 9
HEAD CONTOUR AND PATHLINE PLOT FOR EXTRACTION SCENARIO NO 4 LAYER 2 (LOWER AQUIFER)

0   000   2000
SCALE IN FEET

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Table 12

INPUT AND OUTPUT FILES FOR EXTRACTION SCENARIO NO. 4

Run No.	Rootname Modification	Date	Extension	Filename	Type of File
30	A	07/21/92	BAS	30C0609.BAS	MODFLOW input file
30	A	07/21/92	BCF	30C0609.BCF	MODFLOW input file
30	A	07/21/92	OC	30C0609.OC	MODFLOW input file
30	A	07/21/92	PCG	30C0609.PCG	MODFLOW input file
30	A	07/21/92	RIV	30C0609.RIV	MODFLOW input file
30	A	07/21/92	WEL	30C0609.WEL	MODFLOW input file
30	A	07/21/92	GHB	30C0609.GHB	MODFLOW input file
30	A	07/21/92	EVT	30C0609.EVT	MODFLOW input file
30	A	07/21/92	BCF	30CCELL.BCF	MODFLOW cell-by-cell flow file
30	A	07/21/92	RIV	30CCELL.RIV	MODFLOW cell-by-cell flow file
30	A	07/21/92	WEL	30CCELL.WEL	MODFLOW cell-by-cell flow file
30	A	07/21/92	GHB	30CCELL.GHB	MODFLOW cell-by-cell flow file
30	A	07/21/92	EVT	30CCELL.EVT	MODFLOW cell-by-cell flow file
30	A	07/21/92	OUT	30C0609.OUT	MODFLOW output file
30	A	07/21/92	UFM	30CHEAD.UFM	MODFLOW unformatted head file
30	A	07/21/92	INP	30CPATH.INP	PATH3D input file
30	A	07/21/92	OUT	30CPATH.OUT	PATH3D output file
30	A	07/21/92	DAT	P3DCNFG.DAT	PATH3D data file
30	A	07/21/92	DAT	P3DPLOT.DAT	PATH3D data file
30	A	07/21/92	DAT	P3DFRONT.DAT	PATH3D data file
30	A	07/21/92	DAT	P3DCAPT.DAT	PATH3D data file
30	A	07/21/92	DAT	FRONTXYZ.DAT	PATH3D data file used with SURFER
30	A	07/21/92	DAT	PATHXYZ.DAT	PATH3D data file used with SURFER
30	A	07/21/92	BLN	PATHXY.BLN	PATH3D data file used with SURFER
30	A	07/21/92	BLN	PATHXZ.BLN	PATH3D data file used with SURFER
30	A	07/21/92	BLN	PATHYZ.BLN	PATH3D data file used with SURFER
30	A	07/21/92	GRD	30CCNTR1.GRD	SURFER grid file of head contours
30	A	07/21/92	GRD	30CCNTR2.GRD	SURFER grid file of head contours
30	A	07/21/92	PLT	30CCNTR1.PLT	SURFER plot file of head contours

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Table 12 (Cont'd.)

INPUT AND OUTPUT FILES FOR EXTRACTION SCENARIO NO. 4

Run No.	Rootname Modification	Date	Extension	Filename	Type of File
30	A	07/21/92	PLT	30CCNTR2.PLT	SURFER plot file of head contours
30	A	07/21/92	DAT	XTRWL30C.DAT	Data file containing locations of extraction wells

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1   ## 8.0 EXTRACTION SCENARIO NO. 5

2   ### 8.1 Objectives

3   The objectives for extraction scenario no. 5 were:

4   ■   Refine the number, locations and pumping rates of extraction areas (from extraction scenario no.

5   1) required to capture the downgradient edge of the Newmark plume;

6   ■   Avoid creation of dry cells in the model area during the simulation; and

7   ■   Minimize extraction of uncontaminated groundwater.

8   ### 8.2 Procedure and Data

9   Three simulations were made before the optimum simulation (Run 34D0722) was achieved for extraction

10   scenario no. 5. The procedure described below was followed for achieving optimum Run 34D0722:

11   ■   Run 34D0722 was made using MODFLOW that ran for a time span of 35 years. The transient-

12   state flow model, simulated and calibrated for the time period between January 1986 to December

13   1990, was used as the basis for Run 34D0722. The input data (including the well pumpage) and

14   boundary conditions, used in the calibration of the transient-state flow model, were applied to Run

15   34D0722 for the first five years of the simulation and repeated at 5-year intervals for 30

16   additional years. The input data and boundary conditions are described in more detail in Section

17   3.0;

18   ■   Three extraction areas were added to the well input file. These three wells were located just

19   outside the outer perimeter of the downgradient edge of the Newmark plume. The number,

20   locations, and pumping rates of the extraction areas used in extraction scenario no. 1 were

21   refined. The five extraction areas used in extraction scenario no. 1 were moved from just inside

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1   to just outside the outer perimeter of the downgradient edge of the Newmark plume. Then

2   extraction area nos. 7 and 11 were eliminated.

3   Due to a limitation in the MODFLOW program, extraction of groundwater from the project flow

4   model was not restricted to separate zones within each model layer. Therefore, all three

5   extraction areas were screened throughout layer 2 (the lower aquifer) since it was believed that

6   most of the contamination existed in the lower aquifer. For layer 2 of the project flow model,

7   the screen interval equaled the top elevation minus the bottom elevation (bedrock) for layer 1.

8   Table 13 gives the refined locations of the extraction areas, their pumping rates and screen

9   intervals used in the extraction scenario no. 5;

10   ■ PATH3D was applied to MODFLOW input data, output file and the unformatted head file for

11   Run 34D0722. A grid file of the heads was created through the application of PATH3D. Also,

12   pathlines were created for 37 imaginary particles. Thirty-seven imaginary particles were placed

13   along the outer perimeter of lower two-thirds of the Newmark plume. Table 14 gives the

14   locations of the imaginary particles; and

15   ■ SURFER was used to produce plots of the head contours and pathlines created during the

16   application of PATH3D.

17   **Results and Summary**

18   The head contour plots for layers 1 and 2 (34DCNTR1.PLT and 34DCNTR2.PLT) and the PATH3D

19   output file for Run 34D0722 were analyzed. Figures 10 and 11 display the head contour plots for layers

20   1 and 2, respectively. These figures also display the extraction areas and the imaginary particles with their

21   pathlines. Table 15 lists the MODFLOW, PATH3D and SURFER files associated with Run 34D0722.

22   The results and summary of the analysis are listed below:

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Table 13

EXTRACTION AREA LOCATIONS & PUMPING RATES
FOR EXTRACTION SCENARIO NO. 5

Extraction Area	Model Cell (x,y,z)	Screen Interval (ft)	Approximate Location	Pumping Rate (gpm)
Downgradient Edge of Newmark Plume				
8	(31,39,2)	20 to 580	on Arrowhead Ave.; 150' S/of 14th St.	2000
9	(32,39,2)	-65 to 620	200' E/of Mt. View Ave.; 300' N/of Wabash St.	2000
10	(33,39,2)	20 to 650	250' E/of Sierra Way; on 14th St.	3000

Note: Extraction area nos. 6 & 12 were eliminated after Run 30A0609.
Extraction area nos. 7 & 11 were eliminated after Run 34C0721.

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Table 14

IMAGINARY PARTICLE LOCATIONS FOR EXTRACTION SCENARIO NO. 5

Particle(s)	Model Cell (x,y,z)	Particle(s)	Model Cell (x,y,z)
1	(31,26,1)	20	(34,37,2)
2	(32,26,1)	21	(33,28,2)
3	(33,26,1)	22	(32,38,2)
4	(34,26,1)	23	(31,38,2)
5	(35,26,1)	24	(30,37,2)
6	(36,26,1)	25	(30,36,2)
7	(36,29,1)	26	(29,35,2)
8	(36,28,1)	27	(29,34,2)
9	(36,29,1)	28	(29,33,2)
10	(36,30,1)	29	(29,32,1)
11	(36,30,2)	30	(29,32,2)
12	(35,31,1)	31	(29,31,1)
13	(35,31,2)	32	(29,31,2)
14	(35,32,1)	33	(29,30,1)
15	(35,32,2)	34	(29,30,2)
16	(35,33,2)	35	(29,29,1)
17	(35,34,2)	36	(30,28,1)
18	(35,35,2)	37	(30,27,1)
19	(35,36,2)		

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Table 15

INPUT AND OUTPUT FILES FOR EXTRACTION SCENARIO NO. 5

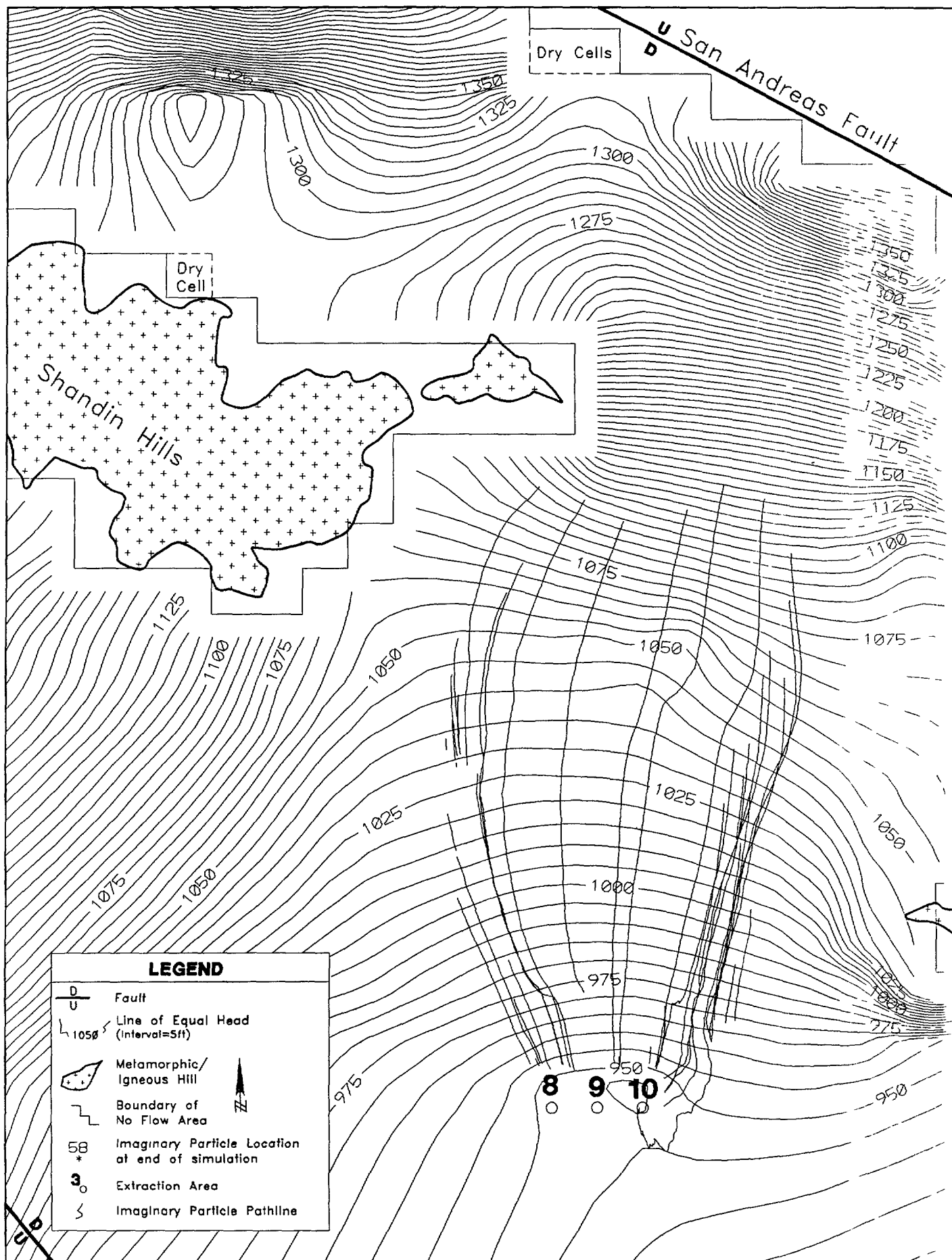| Run No.	Rootname Modification	Date	Extension	Filename	Type of File
34	D	07/22/92	BAS	34B0626.BAS	MODFLOW input file
34	D	07/22/92	BCF	34B0626.BCF	MODFLOW input file
34	D	07/22/92	OC	34B0626.OC	MODFLOW input file
34	D	07/22/92	PCG	34B0626.PCG	MODFLOW input file
34	D	07/22/92	RIV	34B0626.RIV	MODFLOW input file
34	D	07/22/92	WEL	34B0626.WEL	MODFLOW input file
34	D	07/22/92	GHB	34B0626.GHB	MODFLOW input file
34	D	07/22/92	EVT	34B0626.EVT	MODFLOW input file
34	D	07/22/92	BCF	34BCELL.BCF	MODFLOW cell-by-cell flow file
34	D	07/22/92	RIV	34BCELL.RIV	MODFLOW cell-by-cell flow file
34	D	07/22/92	WEL	34BCELL.WEL	MODFLOW cell-by-cell flow file
34	D	07/22/92	GHB	34BCELL.GHB	MODFLOW cell-by-cell flow file
34	D	07/22/92	EVT	34BCELL.EVT	MODFLOW cell-by-cell flow file
34	D	07/22/92	OUT	34B0626.OUT	MODFLOW output file
34	D	07/22/92	UFM	34BHEAD.UFM	MODFLOW unformatted head file
34	D	07/22/92	INP	34BPATH.INP	PATH3D input file
34	D	07/22/92	OUT	34BPATH.OUT	PATH3D output file
34	D	07/22/92	DAT	P3DCNFG.DAT	PATH3D data file
34	D	07/22/92	DAT	P3DPLOT.DAT	PATH3D data file
34	D	07/22/92	DAT	P3DFRONT.DAT	PATH3D data file
34	D	07/22/92	DAT	P3DCAPT.DAT	PATH3D data file
34	D	07/22/92	DAT	FRONTXYZ.DAT	PATH3D data file used with SURFER
34	D	07/22/92	DAT	PATHXYZ.DAT	PATH3D data file used with SURFER
34	D	07/22/92	BLN	PATHXY.BLN	PATH3D data file used with SURFER
34	D	07/22/92	BLN	PATHXZ.BLN	PATH3D data file used with SURFER
34	D	07/22/92	BLN	PATHYZ.BLN	PATH3D data file used with SURFER
34	D	07/22/92	GRD	34BCNTR1.GRD	SURFER grid file of head contours
34	D	07/22/92	GRD	34BCNTR2.GRD	SURFER grid file of head contours
34	D	07/22/92	PLT	34BCNTR1.PLT	SURFER plot file of head contours

Table 15 (Cont'd.)

INPUT AND OUTPUT FILES FOR EXTRACTION SCENARIO NO. 5

Run No.	Rootname Modification	Date	Extension	Filename	Type of File
34	D	07/22/92	PLT	34BCNTR2.PLT	SURFER plot file of head contours
34	D	07/22/92	DAT	XTRWL34D.DAT	Data file containing locations of extraction wells

LEGEND

$\frac{D}{U}$ ———	Fault
$\sim$ 105ø $\lesssim$	Line of Equal Head (Interval=5ft)
⟨icon⟩	Metamorphic/ Igneous Hill
⟨icon⟩	Boundary of No Flow Area
5B *	Imaginary Particle Location at end of simulation
3 ₒ	Extraction Area
$\lesssim$	Imaginary Particle Pathline

San Andreas Fault

Dry Cells

Dry Cells

Dry Cell

Shandin Hills

8 9 10
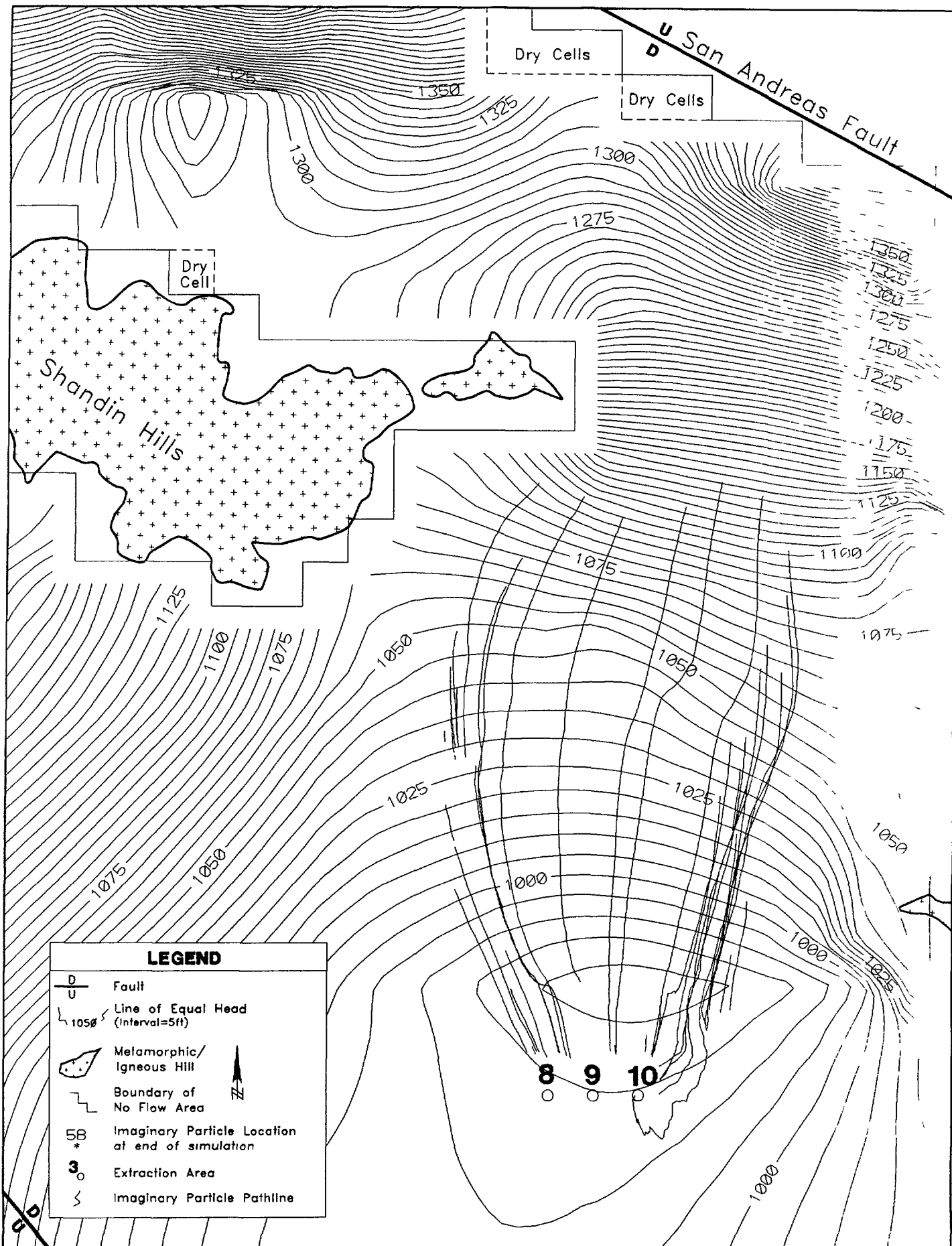
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SUITE 250 NORTH
SACRAMENTO CA 95834
(916) 929 2348

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FIGURE 10
HEAD CONTOUR AND PATHLINE PLOT OF EXTRACTION
SCENARIO NO 5, LAYER 1 (UPPER AQUIFER)

0   000   2000
SCALE IN FEET

LEGEND

D / U (fault symbol)	Fault
1050 (equal head symbol)	Line of Equal Head (Interval=5ft)
(hill symbol)	Metamorphic/ Igneous Hill
(boundary symbol)	Boundary of No Flow Area
58 *	Imaginary Particle Location at end of simulation
3 o	Extraction Area
(pathline symbol)	Imaginary Particle Pathline

Shandin Hills

Dry Cells

Dry Cell

U San Andreas Fault

FIGURE 11

HEAD CONTOUR AND PATHLINE PLOT OF EXTRACTION SCENARIO NO. 5, LAYER 2 (LOWER AQUIFER)

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0   000   2000

SCALE IN FEET

1 ■   All thirty-seven imaginary particles were captured. Most of the particles were captured by the
2   extraction areas. However, eleven of the imaginary particles were captured by some of the
3   existing water-supply wells located within the lower two-thirds of the Newmark plume. These
4   existing water-supply wells that influence the Newmark plume will be discussed in Section 12;

5 ■   The number, locations and pumping rates for the extraction areas located at the downgradient
6   edge of the Newmark plume, which were determined in extraction scenario no. 1, were refined
7   in extraction scenario no. 5. Initially in extraction scenario no. 1, five extraction areas were
8   located just within the outer perimeter of the downgradient edge of the Newmark plume. In Run
9   34C0721 of extraction scenario no. 5, the five extraction areas were moved to just outside the
10   outer perimeter of the downgradient edge of the Newmark plume. Then extraction area nos. 7
11   and 11 (the two outer wells) were eliminated for Run 34D0722;

12 ■   The final pumping scenario described above produced an adequate capture zone in layer 2 (lower
13   aquifer). For layer 1 (upper aquifer), the capture zone extended approximately 1.5 miles
14   downgradient from the edge of the Newmark plume. The refined number and pumping rates of
15   these extraction areas were maintained since the contaminants were believed to be concentrated
16   in layer 2 (lower aquifer); and

17 ■   It was noted that pumping rates for extraction areas in the southeast edge of the Newmark plume
18   had to be increased to rates slightly higher than for those on the southwest downgradient edge of
19   the Newmark plume. It seemed that more groundwater was flowing along the eastside of the
20   Newmark plume.

1   ## 9.0 EXTRACTION SCENARIO NO. 6

2   ### 9.1 Objectives

3   The objectives for extraction scenario no. 6 were:

4   ■   Refine the number, locations, and pumping rates of extraction areas (used in extraction scenarios
5   no. 1 and 2) required to capture the downgradient edge and Newmark wellfield of the Newmark
6   plume;

7   ■   Avoid creation of dry cells in the model area during the simulation; and

8   ■   Minimize extraction of uncontaminated groundwater.

9   ### 9.2 Procedure and Data

10   Three simulations were made before the optimum simulation (Run 35D0724) was achieved for extraction
11   scenario no. 6. The procedure described below was followed for achieving optimum Run 35D0724:

12   ■   Run 35D0724 was made using MODFLOW that ran for a time span of 35 years. The transient-
13   state flow model, simulated and calibrated for the time period between January 1986 to December
14   1990, was used as the basis for Run 35D0724. The input data (including the well pumpage) and
15   boundary conditions used in the calibration of the transient-state flow model were applied to Run
16   35D0724 for the first five years of the simulation and repeated at 5-year intervals for 30
17   additional years. The input data and boundary conditions are described in more detail in Section
18   3.0;

19   ■   A total of four extraction areas were added to the well input file for remediation of the
20   downgradient edge and Newmark wellfield of the Newmark plume. Three of the extraction areas

1   were located just outside the outer perimeter of the downgradient edge of the Newmark plume

2   (same extraction area locations described in extraction scenario no. 5).

3   The fourth extraction area was located in the Newmark wellfield of the Newmark plume. This

4   fourth extraction area and the four existing Newmark wells (same extraction area locations

5   described in extraction scenario no. 2) were used to remediate the Newmark wellfield of the

6   Newmark plume. The four existing Newmark wells were pumped at their normal rates from

7   January 1986 through December 1990. The additional extraction area was added approximately

8   800 feet south of the Newmark wells and was pumped at 800 gpm for 35 years.

9   Due to a limitation in the MODFLOW program, extraction of groundwater from the project flow

10   model was not restricted to separate zones within each model layer. Therefore, all three

11   extraction areas for the downgradient edge of the Newmark plume were screened throughout

12   layer 2 and all five extraction areas for the Newmark area were screened throughout layer 1. For

13   layer 1 of the project flow model, the screen interval equaled the head value minus the bottom

14   elevation for layer 1. The screen interval for layer 1 changed when the head in layer 1 changed

15   during the simulation. Table 16 gives the locations of the extraction areas, their pumping rates

16   and screen intervals used in the simulation;

17   ▪ PATH3D was applied to MODFLOW input data, output, and the unformatted head files for Run

18   35D0724. A grid file of the heads was created through the application of PATH3D. Also,

19   pathlines were created for 68 imaginary particles. Sixty-eight imaginary particles were placed

20   along the outer perimeter of the Newmark plume, from upgradient of the Newmark wellfield to

21   the downgradient edge of the Newmark plume. Table 17 gives the locations of the imaginary

22   particles; and

23   ▪ SURFER was used to produce plots of the head contours and pathlines created during the

24   application of PATH3D.

Appendix M

Table 16

EXTRACTION AREA LOCATIONS & PUMPING RATES
FOR EXTRACTION SCENARIO NO. 6

Extraction Area	Model Cell (x,y,z)	Screen Interval (ft)	Approximate Location	Pumping Rate for yrs 1-5 (gpm)
Downgradient Edge of Newmark Plume				
8	(31,39,2)	20 to 580	on Arrowhead Ave.; 150' S/of 14th St.	2000
9	(32,39,2)	-65 to 620	200' E/of Mt. View Ave.; 300' N/of Wabash St.	2000
10	(33,39,2)	20 to 650	250' E/of Sierra Way; on 14th St.	3000
Newmark wellfield of Newmark Plume				
Newmark 1[a]			NE corner of "A" St. & Western Ave.	
Newmark 2[a]			175' S/of Reservoir Dr.; 40' W/of Magnolia Dr.	0 to 2910[b]
Newmark 3[a]	(23,18,1)	995 to 1248[d]	95' N/of 42nd St.; 280' E/of Western Ave.	
Newmark 4[a]	(23,17,1)	1025 to 1270[d]	65' S/of Reservoir Dr.; 50' E/of Western Ave.	0 to 1585[c]
5	(23,19,1)	995 to 1265[d]	450' W/of 4th St.; 500' S/of 42nd St.	100

Note: Extraction area nos. 6 & 12 were eliminated after Run 30A0609.
Extraction area nos. 2 & 6 were eliminated after Run 34C0721.

[a] Existing water-supply well.

[b] Total pumping rate range for Newmark 1,2 & 3 for 1986 through 1990 was used in the 5-year simulation.

[c] Pumping rate range for Newmark 4 for 1986 through 1990 was used in the 5-year simulation.

[d] Initial head in layer 1 (upper aquifer). The screen interval for layer 1 equals the head value minus the bottom elevation for layer 1.

Appendix M

Table 17

Imaginary Particle Locations for Extraction Scenario No. 6

Particle(s)	Model Cell (x,y,z)	Particle(s)	Model Cell (x,y,z)
1	(31,26,1)	35	(35,24,1)
2	(36,26,1)	36	(35,23,1)
3	(36,27,1)	37	(35,22,1)
4	(36,28,1)	38	(34,21,1)
5	(36,29,1)	39	(33,20,1)
6	(36,30,1)	40	(32,19,1)
7	(36,30,2)	41	(31,19,1)
8	(35,31,1)	42	(30,18,1)
9	(35,31,2)	43	(29,18,1)
10	(35,32,1)	44	(28,17,1)
11	(35,32,2)	45	(27,17,1)
12	(35,33,2)	46	(26,17,1)
13	(35,34,2)	47	(25,17,1)
14	(35,35,2)	48	(24,17,1)
15	(35,36,2)	49	(23,17,1)
16	(34,37,2)	50	(22,17,1)
17	(33,38,2)	51	(21,17,1)
18	(32,38,2)	52	(21,18,1)
19	(31,38,2)	53	(21,19,1)
20	(30,37,2)	54	(21,20,1)
21	(30,36,2)	55	(22,20,1)
22	(29,35,2)	56	(23,20,1)
23	(29,34,2)	57	(24,21,1)
24	(29,33,2)	58	(25,22,1)
25	(29,32,1)	59	(26,22,1)
26	(29,32,2)	60	(27,22,1)
27	(29,31,1)	61	(28,22,1)
28	(29,31,2)	62	(29,22,1)
29	(29,30,1)	63	(30,22,1)
30	(29,30,2)	64	(31,22,1)
31	(29,29,1)	65	(32,22,1)
32	(30,28,1)	66	(32,23,1)

Appendix M

Table 17 (Cont'd.)

Imaginary Particle Locations for Extraction Scenario No. 6

Particle(s)	Model Cell (x,y,z)	Particle(s)	Model Cell (x,y,z)
33	(30,27,1)	67	(32,24,1)
34	(36,25,1)	68	(31,25,1)

1   ## 9.3 Results and Summary

2

3   The head contour plots for layers 1 and 2 (35DCNTR1.PLT and 35DCNTR2.PLT) and the PATH3D

4   output file for Run 35D0724 were analyzed. Figures 12 and 13 display the head contour plots for layers

5   1 and 2, respectively. These figures also display the extraction areas and the imaginary particles with their

6   pathlines. Table 18 lists the MODFLOW, PATH3D and SURFER files associated with Run 35D0724.

7   The results and summary of the analysis are listed below:

8

9   ■   All 68 imaginary particles that were place along the outer perimeter of the Newmark plume were

10   captured. The extraction areas located in the Newmark wellfield captured all the upgradient

11   imaginary particles and four imaginary particles located just downgradient to the Newmark wells.

12   Based on the pathlines of these imaginary particles, the extraction areas located in the Newmark

13   wellfield form a complete capture zone of the portion of the Newmark plume originating

14   upgradient (west and northwest) of the Newmark plume;

15

16   A majority of the imaginary particles (57 out of 68) migrated downgradient and were

17   predominantly captured by the three extraction areas located just outside the outer perimeter of

18   the downgradient edge of the Newmark plume. However, 14 of the remaining 57 imaginary

19   particles were captured by existing water-supply wells located within the lower two-thirds of the

20   Newmark plume. These existing water-supply wells that influence the Newmark plume will be

21   described in Section 12.0;

22

23 ■   The number, locations, and pumping rates for the extraction areas located at the downgradient

24   edge of the Newmark plume were determined in extraction scenario no. 5 and then were

25   combined with the extraction areas for the Newmark wellfield. The capture zones produced for

26   both layers at the downgradient edge of the Newmark plume in this extraction scenario look very

27   similar to the ones produced in extraction scenario no. 5; and

28

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Table 18
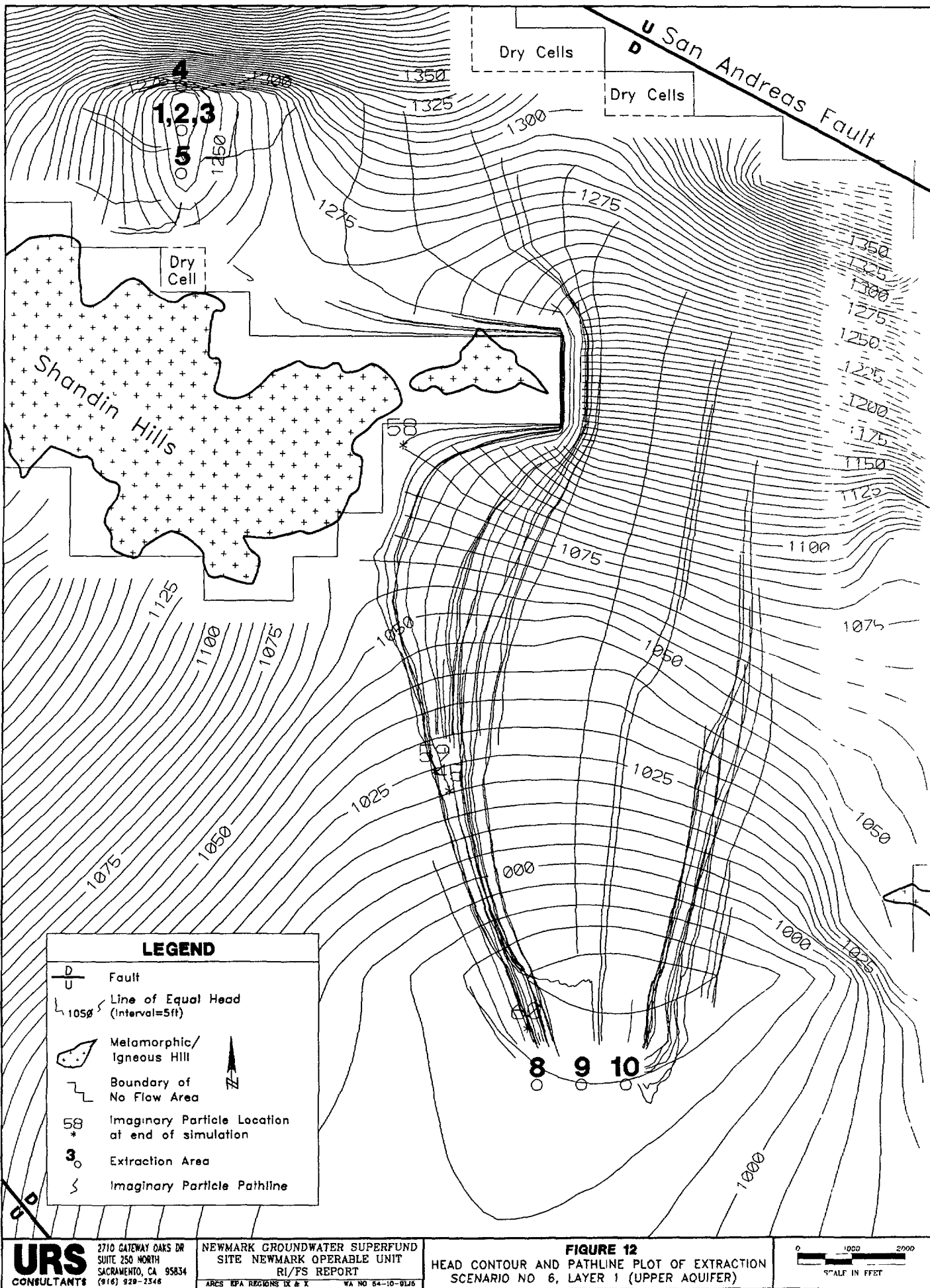
INPUT AND OUTPUT FILES FOR EXTRACTION SCENARIO NO. 6

Run No.	Rootname Modification	Date	Extension	Filename	Type of File
35	D	07/24/92	BAS	34B0626.BAS	MODFLOW input file
35	D	07/24/92	BCF	34B0626.BCF	MODFLOW input file
35	D	07/24/92	OC	34B0626.OC	MODFLOW input file
35	D	07/24/92	PCG	34B0626.PCG	MODFLOW input file
35	D	07/24/92	RIV	34B0626.RIV	MODFLOW input file
35	D	07/24/92	WEL	34B0626.WEL	MODFLOW input file
35	D	07/24/92	GHB	34B0626.GHB	MODFLOW input file
35	D	07/24/92	EVT	34B0626.EVT	MODFLOW input file
35	D	07/24/92	BCF	34BCELL.BCF	MODFLOW cell-by-cell flow file
35	D	07/24/92	RIV	34BCELL.RIV	MODFLOW cell-by-cell flow file
35	D	07/24/92	WEL	34BCELL.WEL	MODFLOW cell-by-cell flow file
35	D	07/24/92	GHB	34BCELL.GHB	MODFLOW cell-by-cell flow file
35	D	07/24/92	EVT	34BCELL.EVT	MODFLOW cell-by-cell flow file
35	D	07/24/92	OUT	34B0626.OUT	MODFLOW output file
35	D	07/24/92	UFM	34BHEAD.UFM	MODFLOW unformatted head file
35	D	07/24/92	INP	34BPATH.INP	PATH3D input file
35	D	07/24/92	OUT	34BPATH.OUT	PATH3D output file
35	D	07/24/92	DAT	P3DCNFG.DAT	PATH3D data file
35	D	07/24/92	DAT	P3DPLOT.DAT	PATH3D data file
35	D	07/24/92	DAT	P3DFRONT.DAT	PATH3D data file
35	D	07/24/92	DAT	P3DCAPT.DAT	PATH3D data file
35	D	07/24/92	DAT	FRONTXYZ.DAT	PATH3D data file used with SURFER
35	D	07/24/92	DAT	PATHXYZ.DAT	PATH3D data file used with SURFER
35	D	07/24/92	BLN	PATHXY.BLN	PATH3D data file used with SURFER
35	D	07/24/92	BLN	PATHXZ.BLN	PATH3D data file used with SURFER
35	D	07/24/92	BLN	PATHYZ.BLN	PATH3D data file used with SURFER
35	D	07/24/92	GRD	34BCNTR1.GRD	SURFER grid file of head contours
35	D	07/24/92	GRD	34BCNTR2.GRD	SURFER grid file of head contours

Table 18 (Cont'd.)

INPUT AND OUTPUT FILES FOR EXTRACTION SCENARIO NO. 6

Run No.	Rootname Modification	Date	Extension	Filename	Type of File
35	D	07/24/92	PLT	34BCNTR1.PLT	SURFER plot file of head contours
35	D	07/24/92	PLT	34BCNTR2.PLT	SURFER plot file of head contours
35	D	07/24/92	DAT	XTRWL35D.DAT	Data file containing locations of extraction wells

LEGEND

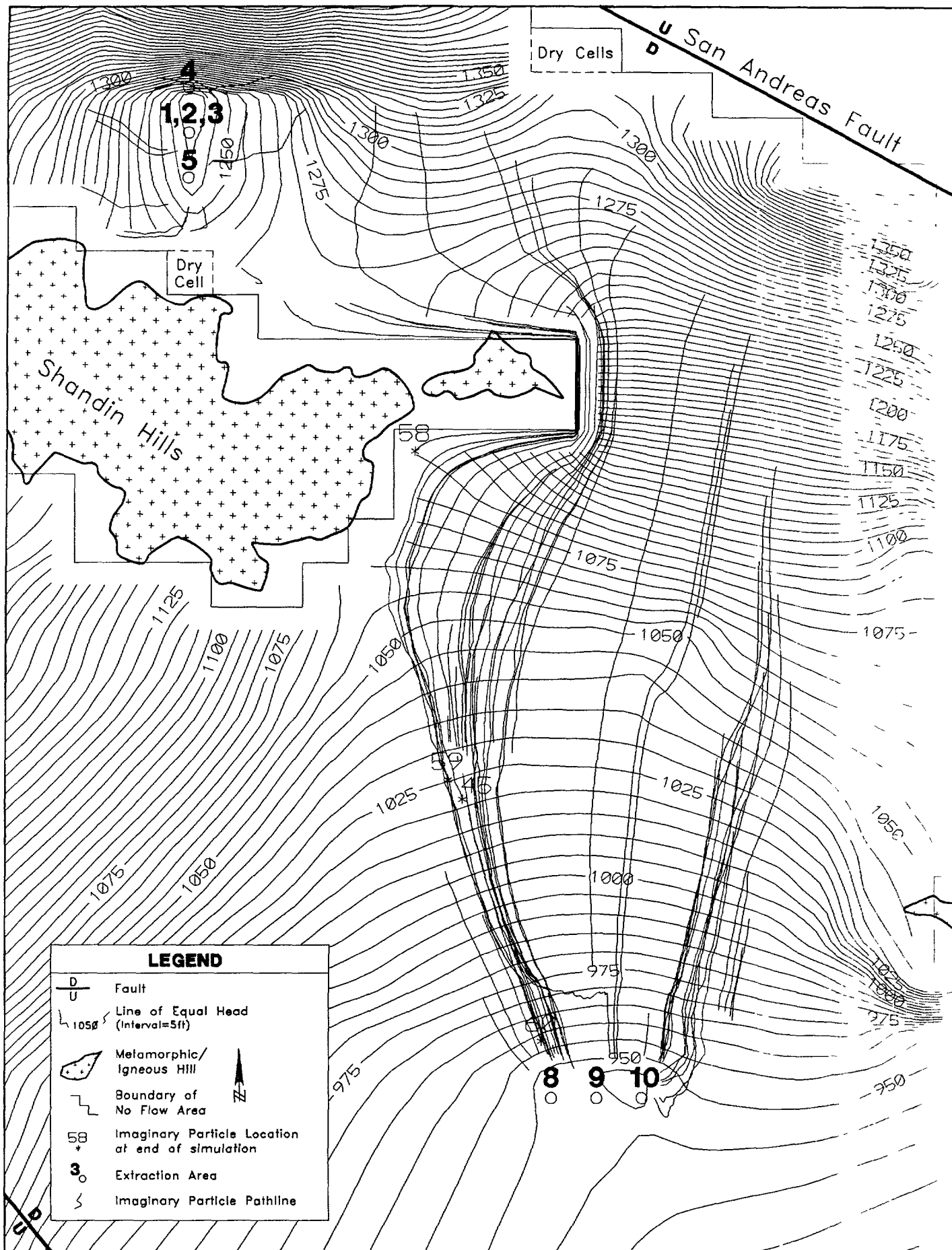|	
ᴰ⁄ᵤ ——	Fault
⌇1050⌇	Line of Equal Head (Interval=5ft)
⬡	Metamorphic/ Igneous Hill
⌐┐	Boundary of No Flow Area
58 *	Imaginary Particle Location at end of simulation
3 ∘	Extraction Area
⌇	Imaginary Particle Pathline

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FIGURE 12
HEAD CONTOUR AND PATHLINE PLOT OF EXTRACTION
SCENARIO NO 6, LAYER 1 (UPPER AQUIFER)

0   1000   2000

SCALE IN FEET

LEGEND

$\dfrac{D}{U}$	Fault
⌐ 1050 ⌐	Line of Equal Head (Interval=5ft)
	Metamorphic/ Igneous Hill
	Boundary of No Flow Area
58 *	Imaginary Particle Location at end of simulation
3 ○	Extraction Area
⌐	Imaginary Particle Pathline

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FIGURE 13
HEAD CONTOUR AND PATHLINE PLOT OF EXTRACTION
SCENARIO NO. 6, LAYER 2 (LOWER AQUIFER)

SCALE IN FEET
0   1000   2000

1   ■   The original pumping rate determined for extraction area no. 5 in the Newmark wellfield (the

2   pumping rate determined for extraction area no. 5 in the extraction scenario no. 2) was refined

3   in the simulations of this extraction scenario. Initially, extraction area no. 5 was pumped at 1000

4   gpm for the five years of simulation. This produced an appropriate size capture zone after five

5   years of simulation. However, it was assumed that pumping extraction area no. 5 at 1000 gpm

6   for 35 years would probably produce too large of a capture zone causing the cells to go dry in

7   the simulation. Therefore, extraction area no. 5 was pumped at 1000 gpm for the first five years

8   of simulation, then was reduced to 900 gpm for the next five years, and finally reduced to 800

9   gpm for the last 25 years of simulation. However, the capture zone still grew over time.

10   Finally, in Run 35D0724 the pumping rate for extraction area no. 5 was reduced to 800 gpm for

11   the entire 35 years of simulation. It was concluded that the capture zone, produced by the normal

12   pumping rates of the Newmark wells and the pumping rate of 800 gpm for extraction area no.

13   5, was of sufficient size for remediating the Newmark wellfield of the Newmark plume.

14   **10.0   EXTRACTION SCENARIO NO. 7**

15   **10.1   Objectives**

16   The objectives for extraction scenario no. 7 were:

17   ■   Refine the number, locations, and pumping rates of extraction areas (used in extraction scenarios

18   no. 1, 2 and 3) required to capture the downgradient edge, Newmark wellfield and middle area

19   of the Newmark plume;

20

21   ■   Avoid creation of dry cells in the model area during the simulation; and

22   ■   Minimize extraction of uncontaminated groundwater.

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1   **10.2   Procedure and Data**

2   One simulation was made before the optimum simulation (Run 36B0726) was achieved for extraction

3   scenario no. 7. The procedure described below was followed for achieving optimum Run 36B0726:

4   ▪ Run 36B0726 was made using MODFLOW that ran for a time span of 35 years. The

5   transient-state flow model, simulated and calibrated for the time period between January 1986

6   to December 1990, was used as the basis for Run 36B0726. The input data (including the

7   well pumpage) and boundary conditions used in the calibration of the transient-state flow

8   model were applied to Run 36B0726 for the first five years of the simulation and repeated

9   in 5-year intervals for 30 additional years. The input data and boundary conditions are

10   described in more detail in Section 3.0;

11   ▪ A total of six extraction areas were added to the well input file for remediation of the

12   downgradient edge and Newmark wellfield of the Newmark plume. Three of the extraction areas

13   were located just outside the outer perimeter of the downgradient edge of the Newmark plume

14   (same extraction area locations described in extraction scenario no. 5);

15   The fourth extraction area was located in the Newmark wellfield of the Newmark plume. This

16   fourth extraction area, and the four existing Newmark wells (same extraction area locations

17   described in extraction scenario no. 2), were used to remediate the Newmark wellfield of the

18   Newmark plume. The four existing Newmark wells were pumped at their normal rates from

19   January 1986 through December 1990. The additional extraction area was added approximately

20   800 feet south of the Newmark wells and was pumped at 800 gpm for 35 years;

21   The last two extraction areas located in the middle area of the Newmark plume (same extraction

22   area locations described in extraction scenario no. 3). These two extraction areas were located

23   adjacent to the northwest edge of Shandin Hills and arranged in a northeast lineament;

24   Due to a limitation in the MODFLOW program, extraction of groundwater from the project flow

25   model was not restricted to separate zones within each model layer. Therefore, all three

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1   extraction areas for the downgradient edge of the Newmark plume were screened throughout
2   layer 2 and all five extraction areas for the Newmark wellfield, and the two extraction areas for
3   the middle area, were screened throughout layer 1. For layer 1 of the project flow model, the
4   screen interval equaled the head value minus the bottom elevation for layer 1. The screen
5   interval for layer 1 changed when the head in layer 1 changed during the simulation. Table 19
6   gives the locations of the extraction areas, their pumping rates, and screen intervals used in the
7   simulation of extraction scenario no.7;

8   ■   PATH3D was applied to MODFLOW input data, output file and the unformatted head file for
9   Run 36B0726. A grid file of the heads was created through the application of PATH3D. Also,
10   pathlines were created for 68 imaginary particles. Sixty-eight imaginary particles were placed
11   along the outer perimeter of the Newmark plume, from upgradient of the Newmark wellfield to
12   the downgradient edge of the Newmark plume. Table 20 gives the locations of the imaginary
13   particles; and

14   ■   SURFER was used to produce plots of the head contours and pathlines created during the
15   application of PATH3D.

16   **Results and Summary**

17   The head contour plots for layers 1 and 2 (36BCNTR1.PLT and 36BCNTR2.PLT) and the PATH3D output
18   file for Run 36B0726 were analyzed. Figures 14 and 15 display the head contour plots for layers 1 and
19   2, respectively. These figures also display the extraction areas and imaginary particles with their pathlines.
20   Table 21 lists the MODFLOW, PATH3D and SURFER files associated with Run 36B0726. The results
21   and summary of the analysis are listed below: